Goddard's Scanning L-band Active Passive (SLAP) Conducts First Airborne Campaign Dedicated to Soil Freeze/Thaw

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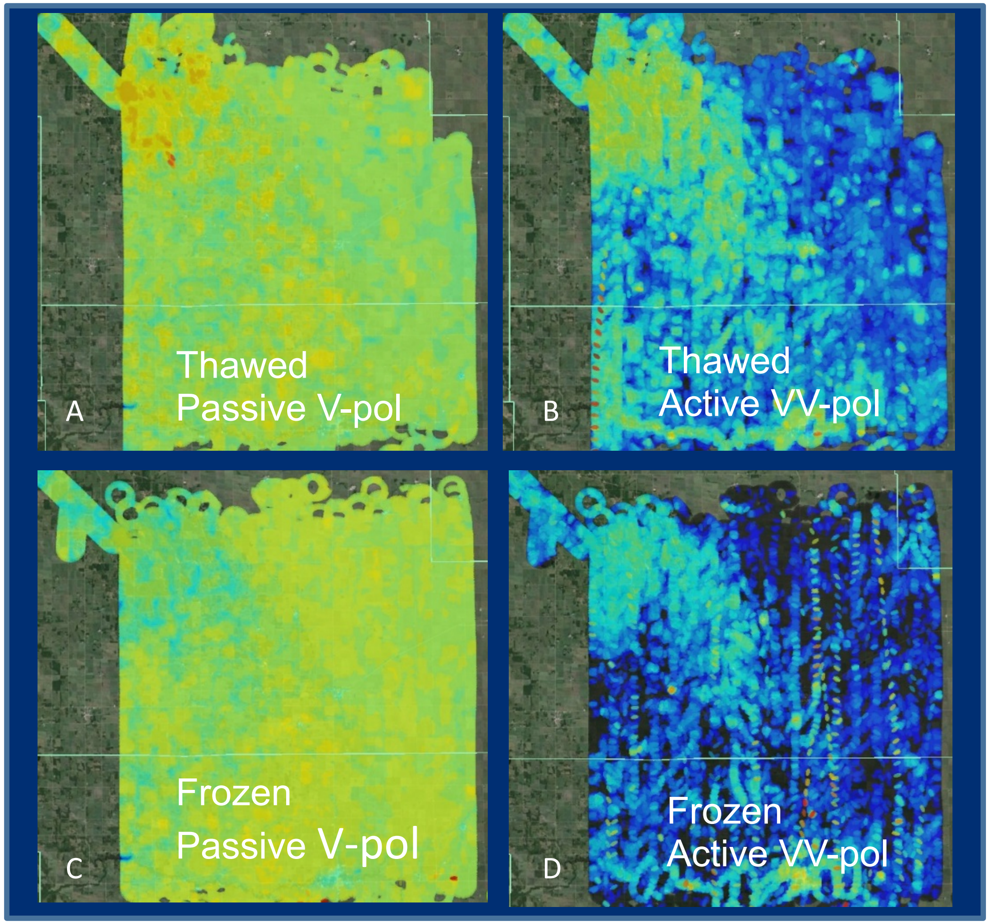

Study Site

Sensitivity to patterns at the scale of individual fields suggests passive and active microwave signatures of frozen vs. thawed soil can yield information on the controlling processes and ramifications for the water, energy, and carbon cycles

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References:

Kim, Y., J. S. Kimball, K. C. McDonald, and J. Glassy,. Developing a Global Data Record of Daily Landscape Freeze/Thaw Status using Satellite Microwave Remote Sensing. IEEE Transactions on Geoscience and Remote Sensing 49, 3, 949-960. 2011. doi: 10.1109/TGRS.2010.2070515.

D. Entekhabi, et al. "The Soil Moisture Active Passive (SMAP) mission," Proceedings of the IEEE , vol. 98, no. 5, pp. 704–716, May 2010. doi: 10.1109/TGRS.2014.2303635.

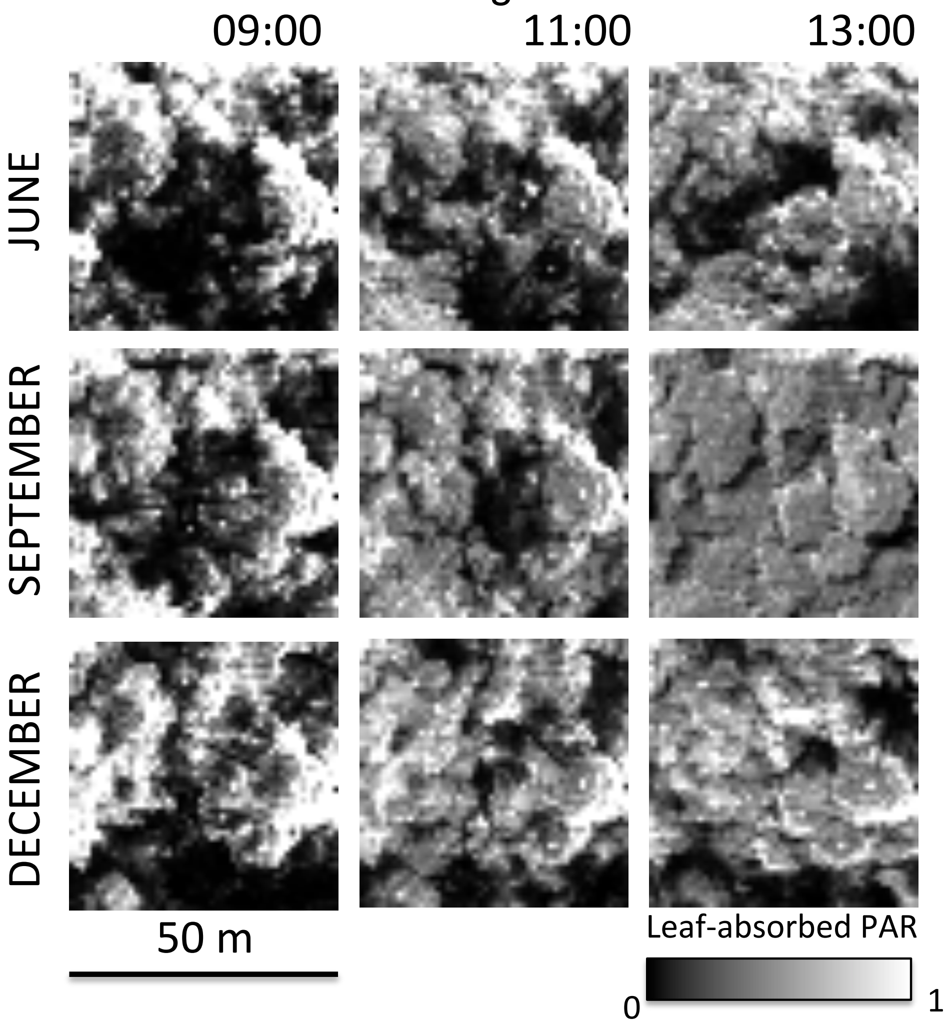
Data Sources:. Quick-look imagery from NASA/GSFC's Scanning L-band Active Passive (SLAP) airborne instrument, both passive and active.

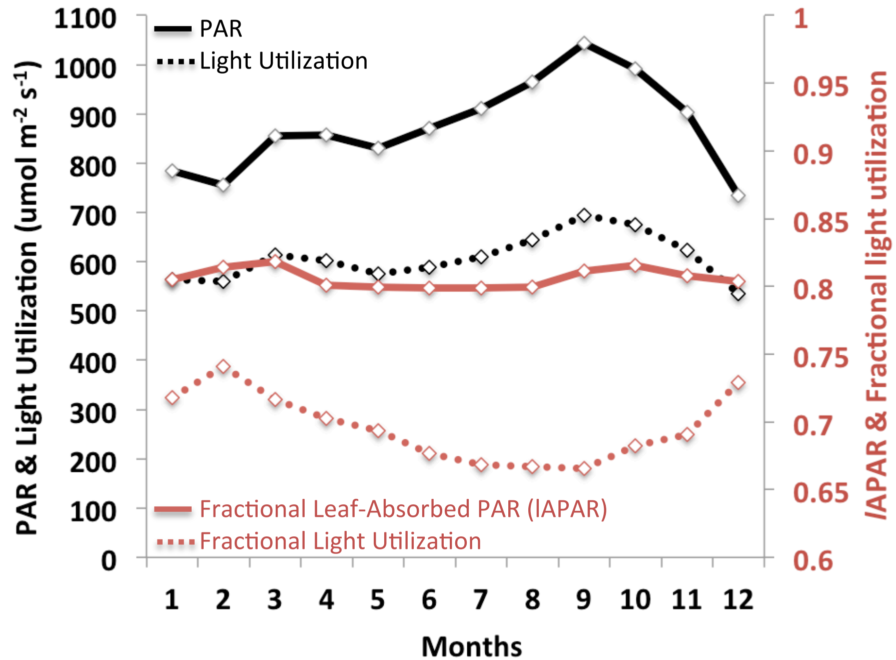
Technical Description of Figures:
Graphic 1: Passive (left panel) and active (right panel) L-band imagery from SLAP airborne sensor. These are uncalibrated quick-look images of brightness temperature (A,C) and radar reflectivity (B,D) superimposed on a Google Earth background image. In the two passive images (A,C), orange/yellow colors show warmer and/or drier conditions while green/blue colors show cooler and/or wetter areas. In the two active images (B,D), yellow/green colors correspond to stronger radar reflectivity while blue/black colors correspond to lower-reflectivity areas. Note the color scale is arbitrary and independent for each image. Thawed observations (A,B) are from Nov. 8, 2015 and frozen observations (C,D) are from Nov 13, 2015. The imaged area is one 36 x 36 km SMAP grid cell, and spatial resolution is ~300m for passive and ~350m for active, both just around the size of the average farm field. The warmer/drier upper left corner of the thawed passive image (A) corresponds exactly with forested areas, which typically have higher brightness temperatures vs. the low/no vegetation of the bare soil and crops or pasture elsewhere. However, the opposite is seen in the frozen case (C), with a colder response of the forest region. The passive and active signatures are a function of physical temperature, soil moisture and freeze/thaw state, surface roughness, and the vegetation cover. Field-to-field variations are related to these factors, and the high sensitivity we see indicates that microwave signatures of frozen vs. thawed soil can yield information on the controlling processes and ramifications for the water, energy, and carbon cycles.
Graphic 2: Location of SLAPex campaign near Carman, Manitoba, Canada (near Winnipeg).
Graphic 3: Normal photograph of typical field sites for SLAPex Freeze/Thaw, taken Nov 15, 2015.
Graphic 4: SLAP preparing for an early morning flight on a NASA Langley King Air (with pilots from Langley and Glenn Centers).

Scientific significance, societal relevance, and relationships to future missions:
Soil freezing and thawing is an important process in the terrestrial water and carbon cycles, marking the change between two very different thermal, hydraulic, and biological regimes. NASA's SMAP mission includes a binary freeze/thaw map as a top-level data product, and describes the freeze/thaw transition as akin to a "switch" for biological processes. When the soil surface freezes or thaws, a significant change in land-atmosphere boundary conditions also takes place for energy and moisture transport, with consequences for atmospheric and hydrological forecasting. While there have been ground-based remote sensing field measurements observing soil freeze/thaw at the point scale, and airborne campaigns that observed some frozen soil areas (e.g., BOREAS), the recently-completed SLAPex Freeze/Thaw campaign is the first airborne campaign dedicated solely to observing frozen/thawed soil with both passive and active microwave sensors and dedicated ground truth, in order to enable detailed process-level exploration of the remote sensing signatures and in situ soil conditions. Future soil moisture missions are expected to also include soil freeze/thaw products, and the loss of the radar on SMAP means that airborne radar-radiometer observations like those that SLAP provides are unique assets for freeze/thaw algorithm development and along with campaigns such as SLAPex may be exploited for future soil moisture missions. SLAP freeze/thaw airborne observations are also directly applicable to the science interests of NASA's upcoming Arctic-Boreal Vulnerability Experiment (*ABoVE*) project.

Amazon Forest Structure Generates Diurnal and Seasonal Variability in Light Utilization

Douglas Morton & Bruce Cook, Biospheric Sciences, NASA GSFC





- Tropical forest 3D structure generates a diversity of light environments.
- Diurnal and seasonal changes in illumination geometry and the fraction of diffuse radiation alters the distribution of photosynthetically-active radiation (PAR) across canopy leaf area.

Key Results: Shadowing and light saturation effects at the leaf level generate seasonality in light utilization, the amount of leaf- absorbed PAR available for photosynthesis, without changes in canopy composition from phenology.

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References:

1. Morton DC, Rubio J, Cook BD, Gastellu-Etchegorry J-P, Longo M, Choi H, Hunter MO, Keller MM. Amazon forest structure generates diurnal and seasonal variability in light utilization. ***Biogeosciences Discussion***, in press.
2. Morton DC, Nagol J, Carabajal C, Rosette J, Palace M, Cook BD, Vermote E, Harding D, North P. Reply to Saleska et al. ***Nature***, in press.
3. Morton DC, Nagol J, Carabajal C, Rosette J, Palace M, Cook BD, Vermote E, Harding D, North P. Amazon forests maintain consistent canopy structure and reflectance during the dry season. ***Nature***, doi:10.1038/nature13006 (05 February 2014).

Data Sources: This study combined airborne lidar data (http://mapas.cnpm.embrapa.br/paisagenssustentaveis/) and *in situ* measurements of leaf area, leaf reflectance, incident photosynthetically active radiation (PAR), and Aeronet aerosol data to evaluate the influence of changing illumination geometry on Amazon forest productivity. Remote sensing and field information was used to generate a 3D forest scene in the Discrete Anisotropic Radiative Transfer (DART) model (http://www.cesbio.ups-tlse.fr/us/dart.html). DART separately tracked light interactions with leaves, woody branches and stems, and the ground surface. Model simulations for five hours per day and one day per month were used to quantify the impact of changing sun angle, cloud cover, and aerosol loading on the distribution of light absorption at the leaf level.

Technical Description of Figures:
Figure 1. The nine figure panels illustrate the influence of changing solar illumination and the fraction of direct/diffuse radiation on the distribution of leaf-level light absorption for the Amazon forest scene. Shades from black to white indicate the leaf absorbed PAR for simulations in three months at 09:00, 11:00, and 13:00. Shadowing and illumination changes are clearly visible, with most uniform distribution of incident light for the September 13:00 simulation with near-nadir solar illumination.
Figure 2. Monthly summary of DART model simulations. PAR (solid black) and modeled light utilization (dashed black), based on a weighted average of hourly DART simulations. Modeled monthly values of leaf-absorbed PAR (lAPAR, solid red) and fractional light utilization (dashed red) are plotted on the right-hand axis.

Scientific Significance: Seasonal dynamics of tropical forest productivity remain an important source of uncertainty in assessments of the land carbon sink. Previous studies have suggested that Amazon forests may respond to increases in light availability during the dry season with large increases in canopy leaf area or leaf reflectance. Morton et al. (2014) used lidar data from NASA's ICESat GLAS instrument and MODIS passive optical data to test these hypotheses, but found no consistent evidence for large net changes in canopy leaf area or reflectance. Instead, that paper hypothesized that seasonal changes in illumination could generate the observed patterns of forest productivity. This study (Morton et al, in press *Biogeosciences Discussion*) confirms the potential for canopy structure and illumination geometry to alter the seasonal availability of light for canopy photosynthesis without changes in canopy composition. These results point to the need for more consideration of forest structure in ecosystem models to account for the impact of changing illumination geometry on tropical forest productivity.

Relevance for Current & Future Missions: The findings have direct bearing on studies of tropical forest productivity from satellite measurements (e.g., OCO-2 xCO_2 and solar-induced fluorescence, SIF), based on the distribution of sunlit and shaded canopy elements, and a range of carbon cycle and ecosystem research efforts funded under NASA Earth Science Programs.

Uncertainties in Global Coastal Ocean Color Products: Impacts of Spatial Sampling

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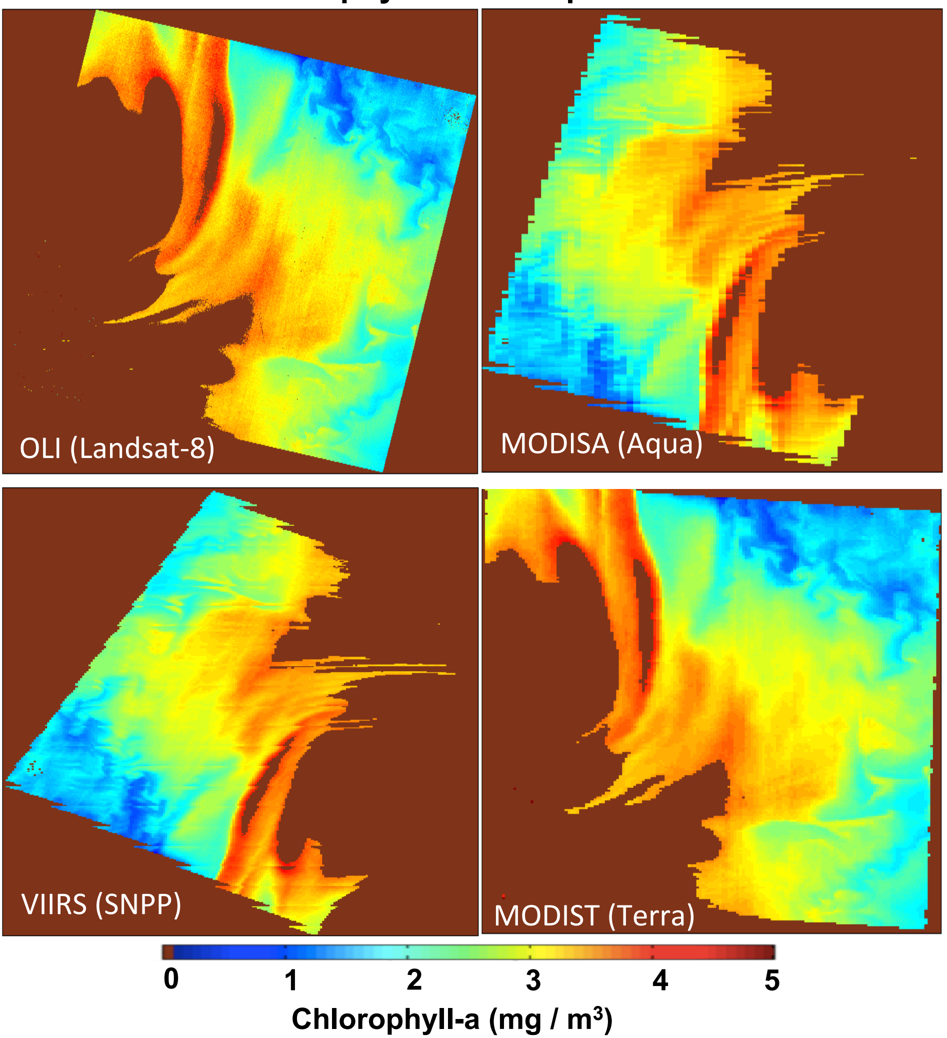
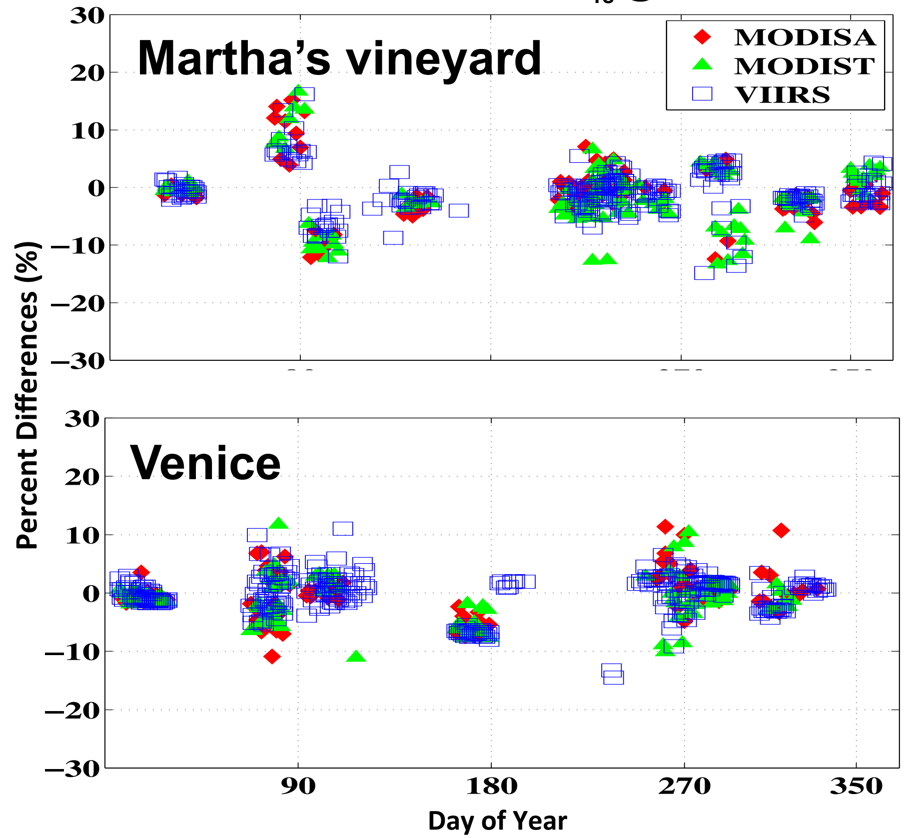
Simulating MODIS and VIIRS coastal-ocean chlorophyll from OLI products



Simulated Spatial Representativeness at Coastal AERONET-OC Sites: R_{rs} @ 443nm



There is up to 15% error in the spatial representativeness of an in-situ radiometric measurement due to varying daily viewing geometries of MODIS/VIIRS.

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Mélin, F., Zibordi, G., & Berthon, J.-F. (2007). Assessment of satellite ocean color products at a coastal site. *Remote Sensing of Environment, 110*, 192-215

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Pahlevan, N., & Schott, J.R. (2013). Leveraging EO-1 to Evaluate Capability of New Generation of Landsat Sensors for Coastal/Inland Water Studies. *Selected Topics in Applied Earth Observations and Remote Sensing, IEEE Journal of, 6*, 360-374

Franz, B.A., Bailey, S.W., Kuring, N., & Werdell, P.J. (2015). Ocean color measurements with the Operational Land Imager on Landsat-8: implementation and evaluation in SeaDAS. *Journal of Applied Remote Sensing, 9*, 096070-096070

Data Sources: The data are provided by USGS to support analyzing products derived from MODIS and VIIRS.

Technical Description of Figures:
Graphic 1 (Left): Examples of MODISA (Aqua), VIIRS, and MODIST (Terra) swath simulations of chlorophyll-a fields derived from the OLI-derived products. The average view zenith angles of the scenes are 58.18^{o}, 51.5^{o}, and 21.5^{o} for MODISA, VIIRS, and MODIST swaths, respectively. The features are reproduced at different viewing conditions. Note that OLI and MODIST are aboard spacecrafts that are in descending orbits in contrast to Aqua and SNPP.
Graphic 2 (Right): The simulated percent difference (PD) biases are shown for two coastal AERONET-OC sites for all available OLI scenes through the year. The PD falls within +/-15% for these sites. MODISA and MODIST show more day-to-day variability than VIIRS.

Scientific significance, societal relevance, and relationships to future missions: The results of this study, for the first time, allows for taking one step forward for a full quantification of the overall error budget analysis of coastal ocean products by isolating the errors due merely to the spatial sampling. The estuaries and coastal oceans are critically important as essential habitat for marine life and a rich source of food for human settlements. Due to the increasing pressure from both climate-related phenomena and human activities in coastal areas, providing repeatable, timely, and reliable ocean color products is now viable for the sustainable development in these regions. We further highlight the need for uniform spatial sampling across the swath (as is for VIIRS) for future ocean color missions like the Pre-Aerosol, Cloud, and ocean Ecosystem (PACE) and the planned GEOstationary Coastal and Air Pollution Events (GEO-CAPE) to enhance our ability in characterizing the instrument performance and validating products for more reliable monitoring of the changing coastal waters.